

I.—*Presidential Address: On the Progress of Geological Investigation in New Brunswick.* By L. W. BAILEY.

(Read May 10, 1889.)

It is, I believe, the custom in our Society, as in others similarly constituted, and one the utility of which has been justified by experience, that he who may have been honored by selection as the Presiding Officer of a Section should make to that Section something of the nature of a formal address, and that this should take the shape of a review, or at least be upon some topic of general interest, rather than upon one which is only local or technical. To one, therefore, whose labours, like my own, have been wholly confined to unravelling the intricacies in the geology of such little known and so complicated regions as that of the interior of New Brunswick, the attempt to meet the requirements of the custom referred to presents unusual difficulty. But, one source of satisfaction connected with the working out of such problems is always present in the fact that their issue has often a bearing far beyond the immediate region in which they are undertaken. It has thus happened, at several different periods since the investigation of New Brunswick geology was begun, that discoveries, at first apparently of little value, have been found to really possess a significance of vast and general moment. I think, therefore, that I cannot do better, upon the present occasion, than to bring before you some facts referring to the progress and present status of New Brunswick geology, and while thus dealing with a theme upon which I may hope to speak with some degree of personal knowledge, to suggest at the same time some points and comparisons which may be found to have a much wider application. As regards the few members of the Section who are not geologists, I must ask their kind indulgence, reminding them at the same time, that many most interesting facts connected with the botany, zoology, agriculture, and climate of different districts, are also connected with and dependant upon their geology, some few of which in the present instance I may take occasion to notice.

The present time seems an appropriate one at which to make such a review as I have proposed, as this year witnesses the issue of the final sheets of the maps prepared by the Geological Survey, in illustration of the geology of New Brunswick. The first efforts in the direction of the preparation of such maps were made in the year 1870, but owing to the great difficulty experienced in obtaining even a probable solution of some of the problems necessary for that purpose, it was not until the year 1880 that the first sheets of the map were actually issued. These were three in number, two in illustration of the southern counties (Charlotte, St. John, and King's) and largely based upon work done in this region prior to the extension thereto of the work of the Geological Survey, and another embracing portions of Queen's, Sunbury, and York Counties, illustrating the position and relations of the Grand Lake coal-field. A special report and map, exhibiting the distribution of the Albert bituminous shales and Albertite deposits of Albert and Westmoreland Counties, had previously been issued in 1877. Following upon the investiga-

tion embodied in these maps and reports, those next undertaken had relation chiefly to the formations bordering upon the Gulf of St. Lawrence and Bay des Chaleurs, while examinations were simultaneously made of portions of the Province lying to the north of the great central coal-field, and along the valley of the St. John. Maps, illustrative of the eastern coast, five in number, were prepared and issued, under direction of Dr. Ells, in 1882, while of those relating to the St. John River region, the first appeared in 1884, a second in 1886, and the last two, completing the entire series for New Brunswick, will be published in the present year.

Prior to the preparation of these maps, two geological maps of the Province had been published, viz., one by Prof. James Robb, in 1850, chiefly based upon the earlier observations of Dr. A. Gesner, though to some extent supplemented and modified by his own, and a second published by Sir W. Dawson in his "Acadian Geology," 1886, and further modified in 1888. That those since issued by the Geological Survey should exhibit a great advance upon the former is no more than would naturally be expected; for though the map of Dr. Robb represents, in a large measure, the results of surveys made with provincial aid, these nevertheless embody the labors, at most, of but two observers, were undertaken at a time when the country was far less generally cleared and less accessible than at present, and belong to a period when the science of geology itself was comparatively in a state of infancy; while that of Sir W. Dawson, though far more advanced than the former, and far more accurate both in its topographical and geological details, was also largely based upon the scattered observations made by himself and others, and largely without governmental assistance. The progress made in the Survey maps, under the direction of Dr. Selwyn, is specially marked in more exact topographical delineation, the result of careful and systematic instrumental surveys, and also in the more positive determination, through fossils and stratigraphy, of the age of the formations represented. In the later sheets, increased attention has been paid to the determination of elevation and the representation of reliefs, but owing to the increased cost involved in work of this kind, the maps, in this particular, are still less complete than could be desired. These maps are then, for the present at least, to be regarded as the final results of the official surveys of New Brunswick. It will, however, be readily understood that, in the course of labours extending over eighteen years, carried on by various observers, and that too in a region remarkable for the complexity of its structure, some diversity of opinion should exist, and that results obtained in the later years, and in the portions of the Province last examined, should, by reflection, tend to modify, to some extent, those gathered in the districts first studied. It will probably, therefore, not be without advantage to make here a brief resurvey of the field, stating which of the earlier conclusions, of general interest, have stood their ground, those which require modification in the light of more recent knowledge, and in what directions further information is desired.

Commencing with the earlier formations, it is gratifying to know that the recognition of Azoic or Archæan rocks, as occurring near the city of St. John, and which was first announced by Mr. Matthew and the author, in 1865,¹ has been amply and fully confirmed. Between these rocks and the overlying Primordial, the evidences of unconformability are

¹ Observations on Geology of Southern New Brunswick, Fredericton, 1865.

clear, varied and widely distributed. It is equally evident that among these Archæan rocks, at least two great groups of sediments are to be distinguished, which, in a general way, bear many features of resemblance to those which in other parts of Canada are known as the Laurentian and Huronian systems. At the same time it is impossible for any one familiar with the rocks of the first named of these great systems not to see that between them and the supposed Laurentian rocks of St. John there are equally striking differences. This is especially to be seen in the greater proportionate amount, in the case of the district last mentioned, of distinctly stratified rocks, such as slates and quartzites, in the comparative absence of coarsely crystalline deposits, of crystalline minerals and ore-beds, and in the much greater regularity and uniformity of the whole. But too much weight must not be given to differences of this kind, more especially as the area in question is itself but very limited. A more satisfactory basis of comparison might perhaps be found in the examination of the microscopic characters afforded by the rocks of the two series, but neither in the case of the supposed Laurentian, nor in that of the Huronian strata, has this yet been done. As regards the Huronian rocks, such examination is especially to be desired, as the greater part of the rocks which make up the bulk of the formation, and which have been referred to as felsites, claystones, porphyries, petrosilex, etc., were described some years prior to the introduction of the present methods of petrological research, and their names, in some instances at least, are probably misapplied.

Another desideratum in connection with these two ancient systems is a better understanding of their true relations to each other, for, though no doubt is entertained by the author as to the fact that the felsitic and schistose rocks referred to the Huronian are more recent than the granitoid and gneissic rocks and the great belts of crystalline limestone which have been regarded as Laurentian, a contrary view has been taken by others; while neither has any satisfactory contact of the two formations been observed, nor any instance in which the conglomerates of the one are unquestionably made up of material derived from the other.

In addition to the areas above referred to as Archæan, several other tracts, of more or less considerable extent, occur in the northern part of the Province, and have also been represented as of Pre-Cambrian age, but the evidence as to these is of less satisfactory character, no overlying Cambrian beds having been here observed, while both their limits and relations are rendered difficult of determination by the uncared, rugged and almost inaccessible character of the region in which they are found. Judged, however, by their lithological aspect, and the fact that they are bordered in places by rocks which are at least as old as the so-called Quebec Group, a good degree of probability is given to the belief that a belt of such rocks traverses the northern interior of the Province, where it also constitutes its most elevated section, and forms the watershed from which flow many of its most important streams.

Of the formations succeeding the Archæan, to none does a greater interest attach than to the Primordial or Cambrian, so assiduously and so successfully studied by our associate, Mr. Matthew. As the important results of these studies have been given to the world through the medium of our own Transactions, it will be unnecessary to speak of them here at length; but to convey some idea of the extent to which they have added to our knowledge of this ancient fauna, it may be sufficient to state that whereas, in the first publi-

cation relating thereto by the late Prof. Hartt,¹ the total number of organic forms recognized was limited to eight genera (four genera, including thirteen species, of Trilobites, and six species of Brachiopods) there are now recognized from the same formation four species of Protozoa (sponges), two of Hydrozoa, one Cystid, twelve Brachiopods, seven Pteropods, two Gasteropods, six Phyllopoas, four Ostracoids, and at least thirty-two species of Trilobites ; among the latter one, the *Paradoxides regina*, being the largest fairly complete example of the genus yet found in any part of the world.

But it is not solely, nor even chiefly, in the recognition of new species that these researches are important. It is largely in the information which they afford as to the relationships of specific types and the phases of their developmental history that they acquire greatest interest and value. They are still further of importance as helping to establish more exactly the range and relations of the entire Cambrian fauna, both as regards its own subdivisions and those of subsequent periods. As originally described under the name of the St. John Group, the formation was regarded as including only the series of dark slates and sandstones, at the base of which were found the *Paradoxides* and other forms by which Prof. Hartt was enabled, in 1868, to fix their age as Primordial, and the probable equivalent of Barrande's Stage C, as represented in Bohemia. At the same time a series of red beds, of considerable thickness, was found to intervene between these fossiliferous strata and those of the older volcanic or Huronian Group, and though at first referred to the latter as an upper member, was subsequently regarded as being more intimately associated with the former. At a still later period, the unconformability of the Primordial series, as including these red beds, to the underlying Huronian, was placed beyond question by investigations extending along their entire lines of contact ; but it is only quite recently that evidence has been found, by Mr. Matthew,² tending to show that between the *Paradoxides* beds and the supposed equivalents of the Huronian, two physical breaks, rather than one, intervene, the red rocks being really unconformable to the overlying as well as the underlying series. A discovery of still greater interest, made at the same time, was that of the occurrence in these same beds, of organic remains which, though few and somewhat obscure, seem sufficient to show the existence, in this part of America, of a fauna older than that of the *Paradoxides* zone, and the equivalent of the Lower Cambrian fauna of Newfoundland, or that of the Caerfai Group of Wales. Thus, the whole Cambrian system at St. John, originally described collectively as Primordial, has now been shown to be divisible into two distinct series, of which the first, Series A-B, the Basal or Georgian Group, includes the *Olenellus* fauna, while the second, Series C, the St. John Group or Cambrian proper, includes part of the Lower and the whole of the Middle Cambrian as recognized in Europe, being equivalent to the Solva and Menevian groups of Hicks, and the *Lingula* flags of Murchison, as well as the *Regiones* B and C of Angelin. Series D, the equivalent of the Potsdam Sandstone, so far as known, is absent from Acadia. Of the groups represented, the St. John Group is further regarded as embracing three stages or divisions, including in the first division four subgroups or bands, each characterized by its own peculiar forms of organic life. Thus, so far as the Maritime Provinces (and New-

¹ Geology of Southern New Brunswick, Fredericton, 1865.

² On a Basal Series of Cambrian Rocks in Acadia, Can. Record of Science, vol. iii, no. 1, 1888.

foundland) are concerned, the Cambrian succession may now be regarded as having been placed upon a substantial basis, and may serve as an invaluable guide towards removing or lessening the obscurity still enveloping that succession elsewhere.

The possibility of making such divisions as have been referred to, and of satisfactorily establishing their correspondence with those of the Cambrian zones recognized in other parts of the world, is sufficient proof of the zeal, care, and ability with which these minute investigations have been carried on by our associate; but I cannot let this opportunity pass without adding my testimony, as that of one personally conversant with the facts, to the energy and untiring perseverance which has led to such important results in the face of difficulties which seemed at one time to be well-nigh insuperable. It may be added that the field in this direction is even now only partially explored, and the studies still in progress can hardly fail to enlarge still further our knowledge of this ancient and earliest known era of undoubted organic existence.

Our attention is again directed, in this connection, to the importance of the use of the microscope in geological investigation, not only as revealing petrological distinctions and conditions of origination not otherwise recognizable, but also as an aid in the search for minute organic relics. Through its means, a series of rocks lying altogether below the first trilobitic beds of the Cambrian, and to ordinary observation utterly barren of fossils, is now known to be filled with the remains of sponges, radiolarians, etc., and therefore shows what we may reasonably expect when the same method of study is applied to the study of like formations, both in the old world and in the new, in which as yet but few observations of this kind have been made.

Of the formation next succeeding the Cambrian, that of the Cambro-Silurian or Ordovician, as occurring in New Brunswick, our knowledge is much less complete and satisfactory. Very large areas, it is true, have, in reports of the Survey, been referred to this horizon, and are so represented upon the accompanying maps, but always with some degree of hesitation, and rather for the reason that this reference is more consistent with such facts as we happen to possess, than that these facts are, for all the areas so represented, entirely conclusive. At one point only, viz., on Beccaguimic River, in Carleton County, have fossils been found, including such genera as *Obolella*, *Acrotreta*, *Lingula*, *Leptæna*, *Orthis*, *Strophomena* (?), *Camerella* or *Rhynchonella* and a Trilobite apparently identical with the *Trinuclens seticornis* of Hisinger, as well as crinoidal or cystidean fragments and sponge-like spicules, which, are certainly Lower Silurian (or Ordovician); but the rocks in which they occur, consisting of hard black siliceous and pyritiferous limestones, are exposed over a very small area, and are quite different in character from anything which has been elsewhere observed in the areas referred to this system. It is certainly very remarkable that nothing corresponding directly either to the thick limestones of the Trenton formation or the Utica shales, with their abundant fossils, has been met with here. The bulk of the strata would seem rather to correspond to the less altered portions of the so-called Quebec Group, consisting chiefly of slates and sandstones, which are occasionally highly colored, but even with the latter, the correspondence, except over limited areas, can hardly be regarded as very close, there being but little to represent the coarse grits of the Sillery formation, and almost nothing to represent the heavy beds of white quartzite, of limestone, or of limestone-conglomerate, which are so conspicuously displayed along the south shore of the St. Lawrence. Another element of doubt in con-

nection with the areas referred to this horizon arises from the finding, at different points within the latter, of fossils which indicate a more recent origin than that assigned to the larger districts in which they occur. Thus, in the very heart of the supposed Cambro-Silurian band, in York County, a narrow belt containing forms of transitional character between the Silurian and Devonian, was found as early as 1879, by the late Chas. Robb; and quite recently still other forms, somewhat obscure but apparently Devonian, have been discovered, by Mr. W. T. H. Reed of Fredericton, in the slates a few miles north of that city. It may thus eventually prove to be the case that within the area ascribed to the Cambro-Silurian, there are considerable tracts of younger strata, either Silurian or Devonian, or both; but the fact that on the north side of the central granite belt the slates in question are so obviously and at so many points met and overlapped by undoubted Silurian strata, taken with the known occurrence of Lower Silurian forms on the Beccaguinic, and of graptolitic slates which are probably Lower Silurian, in the eastern extension of the same belt, near Bathurst, would seem to be sufficient reason for continuing for the present to assign this age to the group in question. It may be added that rocks very nearly resembling many of those which have in New Brunswick been regarded as Lower Silurian, have recently been observed by the writer in northern Maine, where they would seem to be unconformably covered by Silurian conglomerates, made up of their debris; but the determination of the exact age of all these slaty rocks in both countries, is among the most important problems in the geology of this region still requiring solution.

I may add that the same uncertainty rests upon the age of the so-called Kingston Group, of southern New Brunswick, and which in its westward extension becomes, in part at least, continuous with that to which Prof. Shaler has assigned the name of "the Campo Bello Series." By that author, who assigns to strata of the group a thickness of at least 4,000 feet, and compares them with the slates of the Cambridge district in Massachusetts, they are regarded as being Lower Cambrian; but as beds of very similar character occur within a very short distance of the known Cambrian of St. John, and yet bear but little resemblance to the latter, this supposition seems untenable. As they are certainly older than Silurian, and in all probability not Cambrian, they must either be regarded as Pre-Cambrian, the view adopted in the Survey reports, or as Cambro-Silurian.

The rocks of the Silurian system are among the most widely spread and most interesting of those found within the district to which this paper relates. No other formation has determined so large an extent of arable land; none is more remarkable for its physical features, whether of mountains, lakes or rivers, and over none is the distribution of native plants more peculiar. Within it are included the Aroostook region, so well known for its fertility, in northern Maine, and a corresponding "fertile belt" in northern New Brunswick; and it was long since pointed out, by Prof. G. L. Goodale, that many of the species of plants here met with are such as naturally belong to a more southern parallel. Finally, the formation is the first one in which is indicated anything like a definite idea of the early geography of this portion of America.

Although the general age and distribution of the larger part of the rocks referred to this system has been long known, it is only quite recently that any attempt has been made, so far as New Brunswick is concerned, to effect any subdivision of the latter or to determine the relation or equivalency of its different portions. Indeed, this could not

well be done until the entire field had been surveyed and the rocks of this Province brought into connection with the previously studied and more typical sections afforded by the Island of Anticosti and the Gaspé Peninsula. This has now to a large extent been effected, partly by the explorations of Dr. R. W. Ells and his associates, in the peninsula referred to, and more recently by the author, in connection with Mr. McInnes, in the district lying between the Metapedia River and Lake Temiscouata. In the same connection a considerable amount of exploration has been made in the very interesting and highly fossiliferous region of Aroostook County, Maine, and thus the data are now at hand, not only for a comparison of these several localities with each other and the typical section at Cape Gaspé, but also for instituting a similar comparison between the succession and origin of the Silurian strata in northern New Brunswick, Quebec and Maine, and those of the equivalent strata near the Bay of Fundy. Several papers relating to this subject I have already had the honour to lay before the Section; and during our present meeting, it is my desire, in another paper, to discuss at some length, the subject of our early Silurian geography, as indicated by the facts now in our possession. It will therefore not be necessary to dwell upon this topic now, further than to say that we have here, apparently, a pretty full representation of the entire Silurian system, with, however, considerable diversity, both of character and fossils, in the southern as compared with the northern sections of the area considered, and in both with features, particularly of life, which approximate to the geology of Europe rather than to that of the more westerly portions of our own continent. Thus, as regards the former point, while in both districts fossiliferous horizons have been recognized ranging from the lower part of the Niagara formation up to and including the Lower Helderberg, and while in both there are evidences of physical movements, accompanied by igneous extrusions and unconformability, between the lower and higher members of the formation, these in northern New Brunswick and Quebec were followed by a general subsidence, leading to an extensive invasion of the sea, and the formation of thick limestone strata abounding in corals, etc., while in southern New Brunswick, about the Bay of Fundy and Passamaquoddy Bay, the movement was largely upward, leading to the origination of shallow water sediments, with but little limestone.

Again, as regards the European aspect of our Silurian basin, this was early recognized and commented upon by the late Mr. Billings, being seen not only in the large number of genera common to the two, but also in the close approximation or identity of many of the species. It has also been quite fully and ably considered in a recent article by Sir W. Dawson.¹

An interesting discussion of the character and relations of the Silurian rocks as developed about Cobscook and Passamaquoddy Bays, near the boundary between Maine and New Brunswick, has, since the termination of the labours of the Canadian Survey in that region, been made by Prof. N. S. Shaler,² on behalf of the Geological Survey of the United States, but the conclusions reached are, for the most part, in accord with those already announced by the former.

The evidences of igneous activity, to which reference has been made as occurring during the progress of the Silurian era in the Acadian basin, constitutes another of its

¹ On the Eozoic and Palaeozoic Rocks of the Atlantic Coast of Canada, *Quart. Journ. Geol. Soc.*, Nov., 1888.

² *Am. Journal of Science*, July, 1886.

most noticeable peculiarities. No other system, unless it be the Huronian, will compare with it in this respect, and it is noticeable that between the volcanic members of these two great groups, the lithological resemblances are often so close as to make their recognition difficult. For this reason, and in consequence of the not infrequent close association of the two systems in the same district, several considerable areas have been alternately referred to one or the other of these formations; but it is probable that a closer microscopic study of both—a work which is greatly needed—will do much to remove this difficulty.

Still another most interesting fact in connection with our knowledge of the Silurian rocks of New Brunswick has been the discovery, made by Mr. Matthew in 1886, of the remains of Pteraspidian fishes, related to the genus *Cyathaspis* of Lankester, in Division III of that system, or in rocks which are about of the age of the Lower Ludlow, and probably of about the same age as those which in Pennsylvania hold the *Pulcaspis* of Prof. Clappole. This is believed to be our first knowledge of the occurrence of this type of animal life in strata of so great antiquity, so far at least as Canada is concerned.

The most important facts in our knowledge of the Devonian system in New Brunswick were obtained prior to the extension thereto of the work of the Canadian Survey, the rich flora of Perry, Maine, and Carleton, N. B., together with the interesting insect-remains of the latter, having been previously made known to the world through the labours of Prof. Hartt, Mr. Matthew and Sir W. Dawson. A very important limitation, both in the supposed distribution and bulk of this formation, was, however, made in the first year of the survey by the transference to a very much lower (Pre-Cambrian) horizon of a great mass of non-fossiliferous rocks, occupying chiefly the north side of the Bay of Fundy, and which, from their apparently conformable superposition upon undoubted Devonian strata at St. John, had been regarded as a portion of the latter system. In the same year (1870) the rocks of Perry, with their supposed equivalents at St. Andrew's and Point Lepreau, were described by the present author and his associate as much more nearly resembling, both in character and position, the rocks of the Lower Carboniferous formation than those which, at St. John, held similar plant remains. At that time, however, the rocks of St. John were looked upon as the equivalents of the Chemung and Portage Groups, whereas later investigations showed that their position was rather that of the Hamilton formation, if not even still older. At that time also but little had been done in the study of the Devonian basin of Bay des Chaleurs, where our knowledge of the relations of these two formations has since been so greatly enlarged by the observations of Mr. R. W. Ells and others. They bear to each other, in this latter region, the same resemblance lithologically as that which led to their association in Passamaquoddy Bay, but both their relative position and their contained fossils are, according to Mr. Ells, such as render their separation comparatively easy. In view of these facts, it would seem probable that the rocks of the "Perry Group," as all along maintained by Sir W. Dawson, must be accepted as true Devonian, though occupying in that system a position considerably more recent than that of the St. John and Carleton rocks, and being probably the equivalents of the Catskill beds, which in character they nearly resemble.

The discovery, in connection with the Devonian rocks of Bay des Chaleurs, of fossil fishes (*Pterichthys*, *Coccosteus*, *Pteraspis*, etc.) of the same type as those of the Old Red Sand-

¹ Can. Record of Science, vol. ii, no. 4, Oct., 1886.

stone of Scotland, and their careful and elaborate description by Mr. Whiteaves, in the Transactions of our Society, constitute other and most important steps of progress in the development of our knowledge of this system, as they supply another link between the geology of eastern America and that of Europe.

A still more recent discovery in connection with our Devonian system is that of new types of insects and crustaceans, found only last summer by Mr. W. J. Wilson in the same plant-beds at Carleton, near St. John, as those in which Devonian insects were first found by Hartt. The latter, and which were for a long time the earliest insect-remains known from any part of the world, were synthetic forms, combining features of the neuropterous and orthopterous orders. They have since been placed by Scudder in a new Palaeozoic order, on the ground that they antedate both those modern orders and that they represent the source from which these latter have sprung.

The fact that considerable tracts in northern Maine, described in the Reports of the Survey of that State, have been found to contain a well-marked Silurian fauna, has already been referred to. On the other hand, small areas, carrying characteristic fossils of Oriskany age, have been observed by Mr. W. McInnes about the head-waters of the Tobique, in New Brunswick, in a region previously supposed to be wholly Silurian.¹

In the case of the Carboniferous system, the facts ascertained during the period now under review have had to do rather with its economic aspects than with questions of general scientific interest. In the year 1876-77 the distribution and succession of the Lower Carboniferous formation, as represented in King's, Albert and Westmorland Counties, was worked out in considerable detail, with special reference to the so-called Albert shales and the unique and valuable mineral, albertite, associated with the latter.² These investigations amply confirmed the idea of albertite being an altered mineral oil, and distributed much after the manner of ordinary mineral veins, with few, if any, of the characteristics of a true coal, and also indicated the wide extent of the area, fully fifty miles, over which the conditions resulting in these products had operated. In the very same year, however, the original deposit of the Albert mines, which had been so long and so profitably worked, was found to have so greatly decreased in amount as to render its further prosecution useless, and thus what had been for many years the seat of a most active industry as well as a source of considerable revenue to the Province, had to be abandoned. This was not done without long and expensive search for further extensions of the deposit, but though these, and explorations since made, resulted in the discovery of the mineral at quite a number of points, at none of these have the veins proved sufficiently large to warrant their further prosecution.

The existence of true coal in the Grand Lake district in Queen's County was discovered soon after the first settlement of the Province, and the subsequent explorations of Dr. Gesner and others sufficed to show the enormous area over which the rocks of the coal formation are spread within its limits. Prior, however, to the year 1872, but little was definitely known either as to the true thickness of the formation or its probable productive capacity. The idea having been generally entertained by those resident in the Grand Lake region that other and much thicker beds really existed there than the small twenty-two-inch seam which had been so long known and worked near the surface, the members

¹ Geological Survey, Report 1886.

² Report of Progress, Geological Survey, 1876-77.

of the Geological Staff at that time employed in the Province were, in the year above mentioned, directed by the Government of Canada to see what definite information could be obtained upon the subject. The result of the enquiries thus made was to show that the rocks of the Grand Lake coal-field are disposed in the form of a very shallow basin, having a maximum depth of not over 400 feet, and having, on at least three of its borders, rocks older than the coal-formation coming to the surface. The employment of a diamond drill, under the direction of Mr. Ells, gave further confirmation to the results thus obtained, by showing that at many different points, and at depths averaging about 200 feet, similar Pre-Carboniferous rocks were penetrated, and that without passing through any additional seams of coal. Thus, for this particular district at least, the facts ascertained would appear to be decidedly unfavorable to the belief in the existence here of any considerable thickness of coal-rocks or of any great productive capacity. At the same time, however, the remarkable fact was brought to notice, and was subsequently confirmed in other parts of the Province, that the rocks of the coal-formation are unconformable not only to the Devonian, Silurian and other older formations, but to the Lower Carboniferous as well, and may rest directly upon either of these, without the interposition of the others. It may hence follow that the coal-rocks, being deposited horizontally over a folded and eroded surface, may differ greatly in thickness in different localities, and while evidently shallow in the Newcastle region, may elsewhere attain greater volume. So far, however, as observations have yet been made, but little has been found to confirm this belief.

The only other point to which allusion need here be made, in connection with the Carboniferous system, is the reference of considerable portions of that system, in New Brunswick, as well as in Prince Edward's Island, to the Permian Group by Dr. R. W. Ells. The grounds for this reference will be found in the Report of the Geological Survey for 1883.

It may be in place to observe that, in connection with the identification of our different geological formations, and the study of their distribution, character and contained fossils, endeavours have been made to employ these data as a means of working out the varying geography of the periods which they represent, and thus of tracing the historical and physical growth of this portion of America. Among articles bearing upon this subject are some by Mr. Matthew relating to Quaternary changes in the vicinity of St. John, one by the present author relating to ancient erosion in New Brunswick, and another on the history of the St. John River in the same Province, both published in our Transactions; the paper by Prof. Shaler on the geology of Cobscok Bay previously referred to; and finally, an elaborate paper by Sir W. Dawson on the Eozoic and Palæozoic rocks of the Atlantic coast of Canada (Quarterly Journal of Geological Society, November, 1888.) From the observations thus made, the following general conclusions may be regarded as fairly established :—

(1.) The origination of an Acadian basin, as distinct from the other great basins of the continent, by a series of great uplifts antedating the opening of the Cambrian era. While on the north the basin was chiefly limited, as now, by the great chain of the Laurentide hills, with possibly a few outlying islets in the Gaspé peninsula, it was, upon the south, similarly but less completely limited, and separated from the Atlantic, by a series of long and probably low ridges stretching along the southern coast of New

England, continued in the Archæan belts of southern New Brunswick, Nova Scotia and Cape Breton, and finally bending around to connect with those of Newfoundland, thus closing in the same basin on the east. As the result of these uplifts and the accompanying processes of plication and metamorphism, the interior of the basin became, to some extent, protected against the subsequent action of those similar earth-movements which in aftertime affected so seriously other portions of eastern America.

(2.) The following of the period of Archæan uplifts last referred to, by a period of intense volcanic activity, confined for the most part to the same areas as those affected by the former, and synchronous, in all probability, with that of the similar volcanic outbursts of Lakes Superior and Huron. These outbursts were accompanied by, or were attendant upon, movements which chiefly affected the southern border of the Province, adjacent to the Bay of Fundy; the Huronian rocks being here piled up to an enormous thickness, with evidences of frequent changes of level in the course of their accumulation, while in the interior of the Province they are comparatively scarce. The nature of the deposits would indicate a somewhat rapid deposition, and mostly in shallow water.

(3.) The submergence of portions of the basin beneath the sea-level in the Canadian era, as indicated by the limestones of this age bordering the Straits of Belleisle, as well as the boulders, containing relics of the Georgia or Olenellus fauna in the limestone-conglomerates of the Quebec Group. Portions of the rim of the basin were also submerged, as indicated by the character and fossils of the Cambrian formation at St. John and elsewhere, but the movements here would seem to have been quite various, as indicated by the following table, based upon the observations of Mr. Matthew :—

A-B. BASAL OR GEORGIAN SERIES.	{	<i>Etcheminian Stage.</i>	{ Conglomerates, &c.,.....showing littoral origin.
			{ Fine shales,.....indicating deeper water.
			{ Shales and sandstones,.....of shallow water origin.
	{	<i>Georgian Stage.</i>	{ Glauconite shale,.....}
			{ Shales,.....indicating deeper waters.
			{ Shales,.....}
C. ST. JOHN OR ACADIAN SERIES.	{	<i>Stage 1.</i>	{ a. Sandstone,.....}
			{ b. Sandstone,.....} formed in shallow waters.
			{ c. Dark shale,.....formed in deeper waters.
			{ d. Black shales,.....formed in the deep sea.
		<i>Stage 2.</i>	{ Sandstones,.....}
			{ Coarse shales,.....} worm burrows and } shore and shallow waters.
		<i>Stage 3.</i>	{ Black shales,.....}
			{ Ctenopyge beds,.....} with deep-water sponges.
			{ Grey shales,.....}

It is not a little singular that the formation ends with deep-sea deposits, there being nothing to mark that return to or above the sea-level which would naturally usher in the changing conditions and the changing life of a succeeding era.

(4.) A more general submergence in the Cambro-Silurian or Ordovician era, deter-

mining the formation of limestones at Anticosti and to some extent along the St. Lawrence valley, but mostly marked by shallow-water sediments, mingled, according to Sir W. Dawson, with the products of ice-driftage; and followed by a period of disturbance in which these same sediments, including those of the so-called Quebec Group, were compressed and uplifted into the ridges now constituting the Notre Dame range and the axis of the Gaspé peninsula. Further south, similar movements may have affected the Cambro-Silurian strata of central and northern New Brunswick, producing a partial subdivision of the basin into a northern and a southern area.

(5.) A continuation during the first half of the Upper Silurian, of conditions similar to those of the Lower Silurian in south-eastern Quebec and northern Maine, viz., of shallow water sediments, including locally heavy beds of conglomerate, and thick accumulations of volcanic origin, but chiefly limestones at Anticosti; followed, however, by movements which in the northern half of the basin led to a greater depression of the latter and the formation of impure limestones and calcareous shales over much of northern Maine, as well as New Brunswick, but in the south by a movement of elevation which, except at a few points along the coast, raised this region above the sea-level.

(6.) The apparent limitation of purely marine deposition in the Devonian to the northern division of the Acadian basin, and mostly to its first or Oriskany period. Along the southern coast the plant and insect-bearing beds of St. John and Carleton referred to the Hamilton Group, point to their probable origin along the northern border of a trough coinciding in the main with that of the present Bay of Fundy, and about the mouths of rivers which may in part mark the beginning of the modern St. John; while the character and fossils of the slates bordering the central coal-field indicate the continued existence there of the great central basin. The distribution and character of the rocks bordering Bay des Chaleurs, with their remarkable assemblage of land plants and of fishes, both ranging from the Lower to the Upper Devonian, clearly indicate the existence of the depression during the continuance of these periods, as well as its general correspondence with that which now exists. The abundance of trappean deposits in association with these rocks would further indicate that the region was one of considerable instability, and subject to frequent igneous outbursts. Near the Bay of Fundy, and in the interior of New Brunswick, such trappean masses do not accompany the Devonian strata, or only to a limited extent, but important physical movements are indicated by the marked discordance of attitude between the lower and higher beds of the formation.

(7.) An epoch, or epochs, of excessive disturbance, plication and uplift, accompanied by regional metamorphism, and the extrusion of great masses of granite, in the interval between the close of the Silurian era and that introducing the Carboniferous age. The granites have invaded and altered the Silurian strata upon an extensive scale, while they are not known, at least in New Brunswick, to have so invaded the Devonian rocks. The fact, however, that the latter, in common with all the Pre-Carboniferous strata, show abundant evidence of alteration and a parallelism with the granitic axes, gives support to the view that the period of origination of these granites was the close of the Devonian era.

(8.) A general depression in the Lower Carboniferous era, affecting but slightly the northern and western portions of the New Brunswick, but to a greater extent its central and southern parts, submerging all preëxisting valleys, both in New Brunswick and

Nova Scotia, including the great central basin of the former, and partially submerging their bordering hills, to an amount equal, in some cases, to 1,000 feet of their present height. The character of the sediments (largely coarse red sandstone and conglomerates, with impure limestones and beds of gypsum), their impregnation with salt and comparative paucity of marine fossils, indicate a shallow water origin and general conditions similar to those of the Salina period of the Silurian of New York. The close of the era is marked by frequent igneous outflows, by long-continued and extensive denudation and, in some instances, by uplifts, leading to unconformity with the overlying coal-measures.

(9.) The replacement, in the Coal era, of the bays, straits, shallow basins and evaporating flats of the Lower Carboniferous by fresh-water swamps and bogs supporting the coal vegetation. In northern and central New Brunswick, the movements involved in this and succeeding changes, though affecting large areas, were but small in amount, the coal seams being few, and the entire thickness of the formation but slight. In Nova Scotia, as is well known, the thickness is enormous, and includes coal beds remarkable alike for their number and magnitude. In the former, over the central counties, the strata are still very nearly horizontal; along the Bay of Fundy they are more highly inclined, with numerous faults and dislocations; in Nova Scotia they are thrown into numerous basins, showing similar evidences of powerful physical movements.

(10.) Finally, with the changes marking the New Red Sandstone era, a depression and deepening of the Bay of Fundy trough, followed by igneous exursions along its bed, and subsequent elevation to form the North Mountains of Nova Scotia and the Island of Grand Manan, the Acadian basin assumes essentially its present physical aspect, subsequently to be broken only by the events connected with the origination and decline of the great Glacial era, synchronous in all probability with the first appearance of man.

Passing now to these more recent formations, we find, as regards the Quaternary geology of New Brunswick, that, in addition to numerous more or less scattered observations made by nearly all the field observers, special study of this subject has been made both by Mr. Matthew and Mr. Robert Chalmers, the last named gentleman being still engaged in the prosecution of this work. The members of the Section are probably already familiar with the more important conclusions of Mr. Chalmers, as set forth in an elaborate contribution to the memoirs of the Society, and in an article on the glaciation of eastern America in the 'Canadian Record of Science.' These views are of great interest and importance as tending to modify, to a large extent, the opinions previously held as to the character, amount and direction of ice-action in this region in glacial times, and as giving confirmation to the view, so long and ably advocated by Sir. W. Dawson, that the glaciation of this part of the continent was the result of *local* rather than *continental* glaciers, assisted by icebergs, at a time when the country stood *below* its present level. A highly important work in this connection is the preparation, by Mr. Chalmers, of a series of maps, duplicating the geological maps referred to in previous pages, but in which the geological distinctions are replaced by others showing the surface features of the country, the distribution of the various Quaternary deposits, the character of the soil, the distribution of forests, peat bogs, plains, etc. These, when completed, will be of the greatest possible service, not only in connection with the wants of intending settlers, but also in any discussion of the facts of our Quaternary history.

The subject of the prehistoric human occupation of Acadia is one of considerable interest, and although, according to the organization of our Society, it is one which properly appertains to another Section, it is really quite as appropriate to our own, and a few facts relating thereto may be acceptable.

Among the most important investigations connected with this subject, so far as New Brunswick is concerned, are those of the recognition and exploration of the shell-heaps, which are found at different points along the coast, and especially about the shores of Passamaquoddy Bay. Some of these were very fully examined by the late Prof. S. F. Baird, about fifteen years ago, and many interesting articles were obtained, which are now in the collections of the Smithsonian Institution at Washington, but of which no published description has yet been made. Others were explored by a committee of the Natural History Society of St. John, and in their Proceedings is contained a very interesting account, from the pen of Mr. Matthew, of what was evidently an ancient Indian village, at the mouth of Bocabee River, in Charlotte County. In the interior of the Province, scattered relics, chiefly the coarser stone implements and arrow-heads, are of common occurrence, and with these are sometimes found such articles as pipes, pottery, wampum, net-sinkers, pendants etc., often somewhat elaborately ornamented. The coarser and finer relics, including both chipped and polished implements, are, however, promiscuously mixed together, and no facts have been observed from which, in any case, any high degree of antiquity can be inferred. An article by the author, summing up the facts upon this subject, and accompanied by photographic illustrations, is contained in the Sixth Bulletin of the Natural History Society of St. John (1887). This, it is hoped, will soon be followed by a similar article, by Mr. Matthew, upon the prehistoric relics of the coast.

The author cannot close this brief review of scientific progress in New Brunswick without some reference to work which, though not directly geological, must be of some interest to the geologist, as it will also be to other members of the Section. I allude to the advances made in our knowledge of the botany and zoology of the Province. As regards the former, much interesting and valuable work has been done by various local observers, in the way of adding to the lists of species occurring within our limits, or of more accurately defining the range of their distribution; but by far the most important contribution to the subject is that of the systematic synopsis of our entire flora, by Prof. James Fowler, and which has since been incorporated in the still more extensive and elaborate flora of the Dominion, published under the auspices of the Geological and Natural History Survey, by Prof. Macoun. A valuable supplement to the work of Prof. Fowler, which is confined to terrestrial forms, is that of Mr. G. U. Hay and Mr. A. H. MacKay, on the marine Algae of New Brunswick, and which was published in Volume V of our Transactions. An interesting and thoughtful article, showing some of the relations of our plant distribution to the climate and physical conditions affecting it, was published by Mr. Matthew in 1869, under the title "The Occurrence of Arctic and Western Plants in Continental Acadia,"¹ and a somewhat similar article, by Prof. Fowler, "Arctic Plants growing in New Brunswick," in Volume V of our Transactions.

Among important papers bearing upon the subject of our zoology are those of Mr.

¹ Can. Naturalist, June, 1869.

Montague Chamberlin on the distribution and habits of our native birds; those of Mr. W. F. Ganong on the distribution of the cray-fish; on the introduction of *Littorina littorea*; on the marine Mollusca of New Brunswick, and finally, within the last year, on the Echinodermata of New Brunswick.

It will, I think, be admitted that scientific work has not been backward in the section of the Dominion to which I have this evening directed your attention, while to the Royal Society is due, in no small measure, the possibility of making known its results to the scientific world.

